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Experimental investigation of biological and mechanical properties of CoCrMo based selective laser melted metamaterials for bone implant manufacturing

Che Ghani S.A.[a], Mohamed S.R.[a], Sha'Ban M.[b], Wan Harun W.S.[a], Md Noar N.A.Z.[c]

Save all to author list

[a] Human Engineering Group, Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang, Pekan, Pahang, 26600, Malaysia

[b] Department of Biomedical Science, Kulliyah of Allied Health Sciences, Internaltional Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, Kuantan, Pahang, 25300, Malaysia

[c] Department of Mathematic, Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang, Gambang, Pahang, 26300, Malaysia

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Abstract

Metamaterials are composed of structural elements and their properties are derived mainly from the inner structure of the elements, rather than the properties of their constituent material. In this study, mechanical and biological properties of metamaterial made by selective laser melted cobalt chrome molybdenum (CoCrMo) were studied. Metamaterials of diamond and square shapes unit cells with 1.5-2.5 mm strut length and 0.4-0.6 mm strut thickness was prepared by layer-by-layer additive manufacturing technique. The metamaterials demonstrated excellent biological property under MTT assay cytotoxicity after 14 days cell cultured. Comparisons of the experimental data between two unit cell types made by compression tests exhibited that the stiffness of square shape is always higher 20% than those of diamond type, nonetheless all the tested materials satisfy the young's modulus of human cancellous bone . Furthermore, the compression tests also resulted in determining both unit cell types with strut thickness 0.6 mm and strut length 1.5 mm to meet the compressive strength of human cortical bone . The tailored metamaterials by modifying the unit cell sizes and shapes of fabricated bone implant can be achieved by using additive manufacturing technique. The design concepts of internal structures by determining the properties of metamaterials demonstrated in this study will be valuable in future biomedical applications. © 2020 The Authors.

Author keywords

Additive manufacturing ; Biological properties ; Mechanical properties ; Metamaterials ; Orthopaedic implants

Engineering controlled terms

3D printers; Additives; Biomechanics; Cells; Chromium alloys; Cobalt alloys; Compression testing; Compressive strength; Cytology; Elastic moduli; Medical applications; Metamaterials ; Molybdenum alloys; Struts; Ternary alloys

Engineering uncontrolled terms

Biological properties ; Biomedical applications; Constituent materials; Experimental investigations; Human cortical bone ; Internal structure; Manufacturing techniques; Structural elements

Engineering main heading

Bone

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Che Ghani, S.A.; Human Engineering Group, Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang, Pekan, Pahang, Malaysia; email:anwarcg@ump.edu.my
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